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ABSTRACT

Hawaiian monk seal, Monachus schauinslandi, births at Kure Atoll have steadily declined from about 30 pups per year in the late 1950's and early 1960's to a single pup in 1986. The cause of this decline is primarily attributed to recreational beach activities of the U.S. Coast Guard. Although some restrictions were placed on these activities in the late 1970's, the effects of the earlier harassment will continue to be felt for many years.

The immature female monk seal population at Kure Atoll, now numbering 16 individuals, is the product of two recovery activities being conducted by NMFS. One project, Head Start, involves the temporary captive maintenance of all weaned females born at the atoll and the other entails relocation of female pups from another breeding location to Kure Atoll. The result is a high ratio of immature to mature females which bodes well for the future growth of the population, if beach disturbance does not reduce survival of these females or impact their fidelity to Kure Atoll.

Future population changes under different managemant options are presented using a projection model. Assuming further reductions in beach disturbance of the seals, population growth is expected with each option, however, continuation of the present NMFS efforts to increase the numbers and survival rates of young seals will greatly affect the population growth rate.

To ensure recovery of the Kure Atoll monk seal population, the most critical need is a further reduction in beach disturbance. This and other recommendations to optimize recovery are presented in the report.

INTRODUCTION

Kure Atoll is located at the northwestern end of the Hawaiian Archipelago and has been one of the major hauling out and breeding locations of the endangered Hawaiian monk seal, Monachus schauinslandi (Kenyon and Rice 1959; Johnson et al. 1982; Gerrodette 1985). The breeding range of the Hawaiian monk seal also includes the other atolls and islands within the Northwestern Hawaiian Islands (NWHI). Total beach counts of monk seals throughout the NWHI have declined by more than 50% since 1957 (Kenyon and Rice 1959; Rice 1960; Johnson et al. 1982). These data also show that Kure Atoll beach counts have declined over 80% since 1958. Observations on monk seals before 1969, including some records of early human impacts on the species, and the natural history of Kure Atoll can be found in Woodward (1972).

In 1960 the U.S. Coast Guard (USCG) began construction of a loran station on Green Island, the only large, vegetated, and stable island at Kure Atoll. The station became operational in 1961 and continues in operation to date with a contingent of approximately 20 personnel. Human disturbance of the seals on the beaches of Green Island, in the form of frequent beachwalking, use of vehicles on the beach, and presence of dogs has been cited as the primary cause of the population decline. Kenyon (1972) reported that this human disturbance caused females to abandon their preferred pupping habitat on Green Island and begin to use the much smaller and less stable sand islets (Shark, Sand, and Stark Islands) as birth sites (Fig. 1). These locations offered female-pup pairs no shelter from storms and no shallow nearshore areas in which they could swim and rest in the water while protected from sharks. These smaller islands were also visited by station personnel, although less frequently than the beaches of Green Island, and on at least one occasion were visited by a helicopter from Midway. The islets can disappear in hours with changes in currents and wave action during storms and extreme tides, which clearly make them unsuitable as good pupping and nursing habitat.

Survival of monk seals born at Kure Atoll in the 1960's and 1970's was low. Wirtz (1968) found that all but 1 of 62 pups born in 1964 and 1965 either disappeared or were known to have died between 16 and 74 days of age (weaning normally occurs at about 40 days). Some of the dead pups observed by Wirtz were believed killed by sharks which are nearshore from late spring through mid-summer. Other pups had open back wounds surrounded by lacerations and bruised tissue, which Wirtz believed may have been inflicted by adult male monk seals. Subsequent observations by others have confirmed that this type of injury can be caused by adult male seals (Johnson and Johnson 1981; Alcorn 1984; Johanos and Kam 1986). Pup survival also appears to have remained low in the 1970's. High beach counts of immature seals older than pups ranged from zero to five animals from 1976 to 1980 (Johnson et al. 1982).

Poor pup survival between the early 1960's and 1980 resulted in very low annual recruitment of breeding seals. This caused Kenyon (1980) to suggest that the remaining adult females at Kure were old animals, probably born before USCG occupation of Green Island, and that they would not be

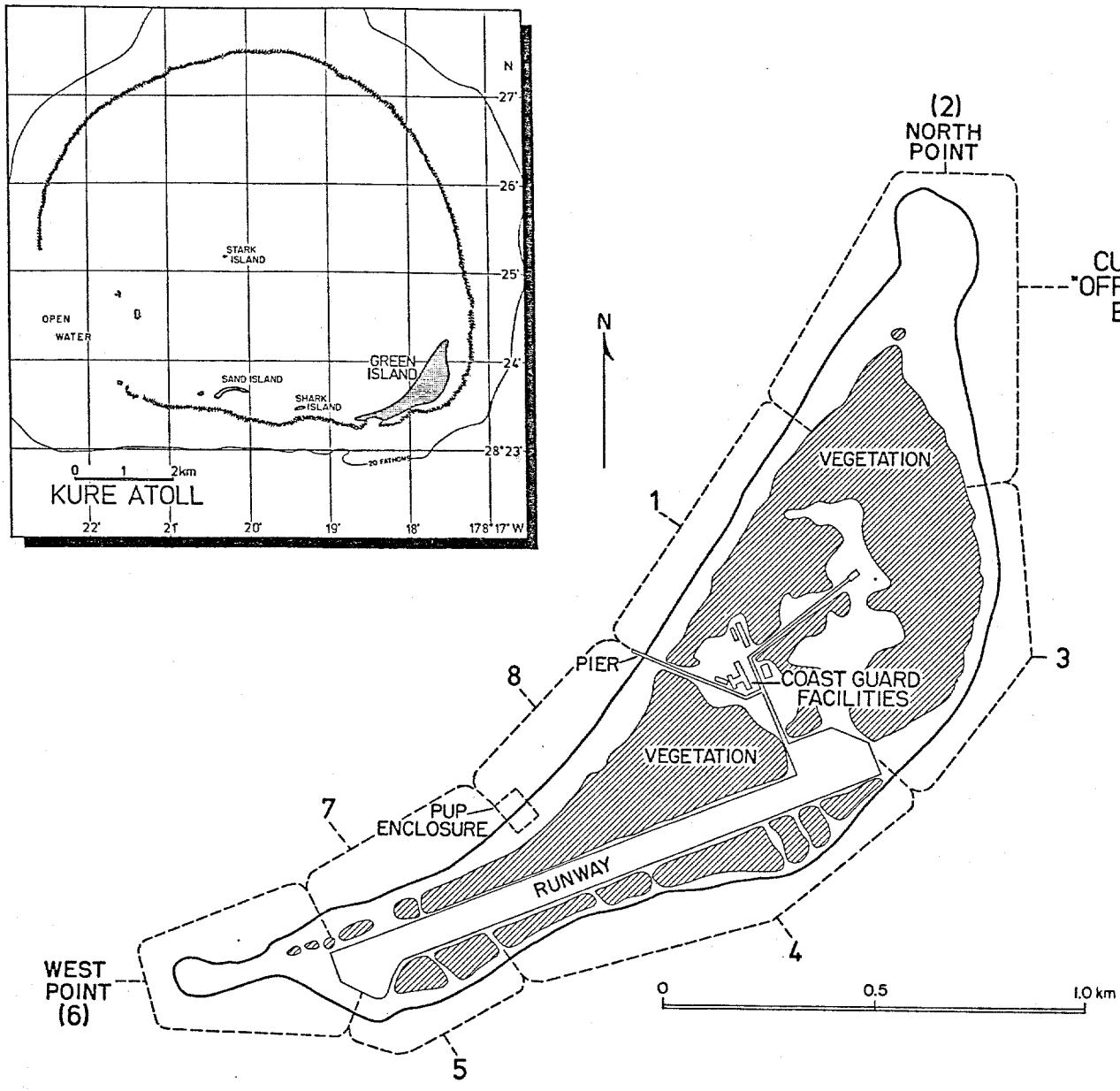

Figure 1.--Map of Green Island, Kure Atoll, showing sector designations used in making seal counts. Inset map shows locations of smaller sand islands at Kure Atoll.

productive much longer. This has, indeed, been the case. Births declined from near 30 pups per year in the late 1950's and mid-1960's (Kenyon and Rice 1959; Rice 1960; Wirtz 1968) to 9 to 10 pups per year from 1977 through 1980 (Johnson et al. 1980; Kenyon 1980; Johnson et al. 1982), 10 pups in 1981 (Gilmartin et al. 1986) and then 3 to 5 pups per year (NMFS unpubl. data) until 1986, when only one male pup was born (Fig. 2).

Beach disturbance causes monk seals, especially adult females, to spend more time in the water and to seek more isolated refuges. More time in the water means greater exposure to sharks and aggressive adult males, resulting in higher mortality rates. The fact that human activity alone on the beach will deter monk seals from hauling out is best illustrated by changes which have occurred at Tern Island, French Frigate Shoals (Fig. 2). During USCG occupation of Tern Island from the 1950's until July 1979, the number of seals using the beach was never more than a few individuals (Amerson 1971; Kenyon 1972; DeLong et al. 1976; DeLong and Brownell 1977; Kenyon and Rauzon 1977). Immediately after departure of the USCG in 1979 and occupation of the island by the U.S. Fish and Wildlife Service, the beach counts of seals began to rise, and in subsequent years continued to rise dramatically (Fiscus et al. 1978; Rauzon et al. 1978; Rauzon 1979; Schulmeister 1981; USFWS unpubl. data). The U.S. Fish and Wildlife Service restricts access to all beaches at Tern Island to that which is necessary for research purposes only.

Since 1976 USCG regulations have eliminated the recreational use of vehicles on the beaches of Green Island, dogs have been barred from the station, and a seal refuge area at the north point of Green Island has been designated "off limits" to station personnel. These changes, together with more recent awareness and concern for the plight of the monk seal by most station personnel, have reduced the level of disturbance on the atoll's beaches. Although pupping activity has been declining, all births at the atoll since 1982 have been on the historical rookery beaches of Green Island.

In 1980 the Hawaiian Monk Seal Recovery Team reviewed the available information on the status of the monk seal at Kure Atoll. The decreasing number of births together with the apparent low survival caused concern that recruitment of breeding seals was so low that survival of the Kure Atoll seal population was in jeopardy (Gilmartin 1983). The team believed that the loss of Kure Atoll pups was probably induced by human disturbance on the beaches followed by trauma due to sharks and adult male seals. It also recognized that natural reef toxins (Gilmartin et al. 1980), disease, and congenital problems might also contribute to the high disappearance rate. However, these other factors do not now appear to contribute significantly to low survival of young seals at Kure Atoll (Gilmartin et al. 1986).

In the following sections, the potential effects of two recovery projects directed at increasing the number of female seals at Kure are discussed, the present status of the Kure Atoll monk seal population is presented, and future population changes under different management options are discussed using a projection model. Finally, we recommend actions

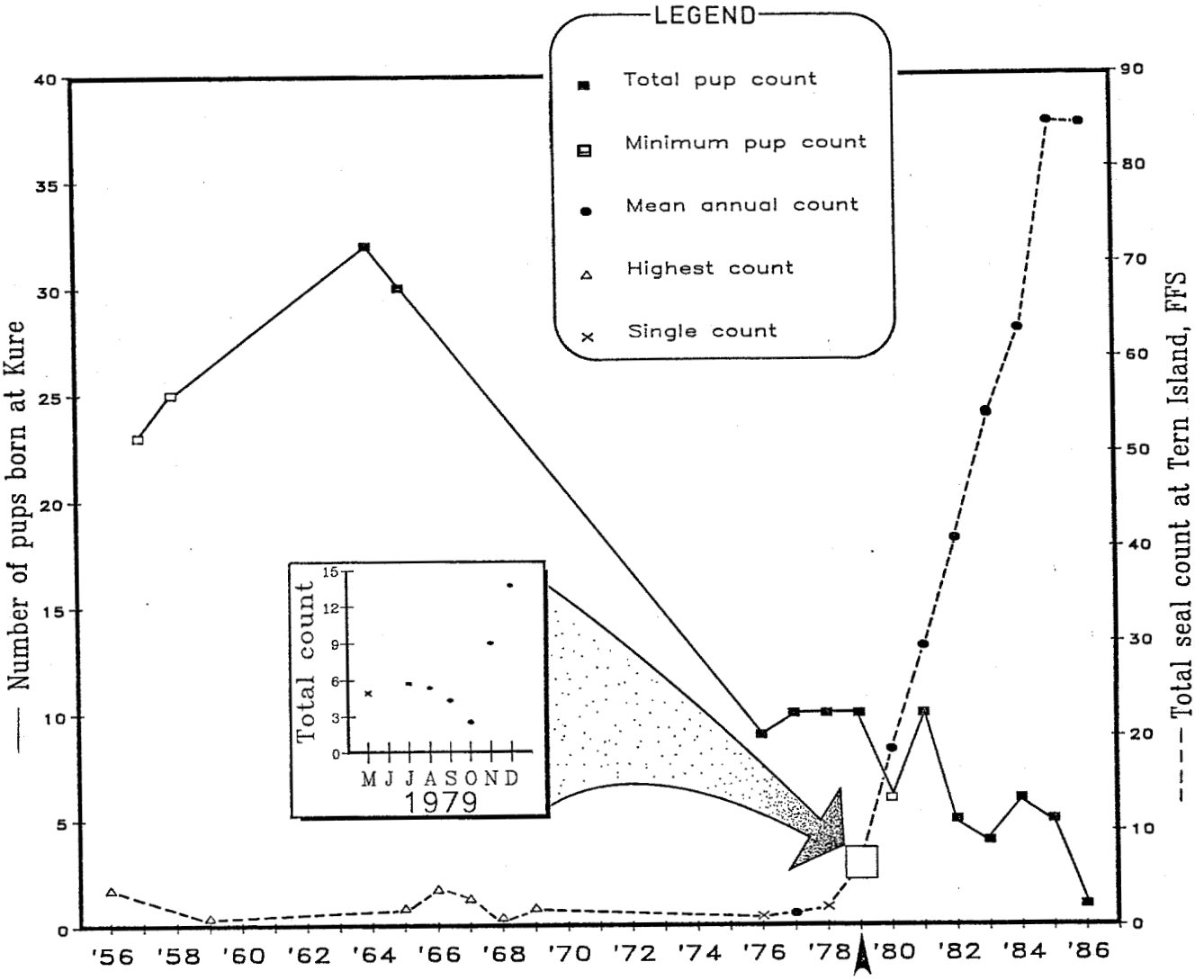

Figure 2.--Number of monk seal pups born at Kure Atoll (solid line) and total seal counts at Tern Island, French Frigate Shoals (dashed line), 1956-86. The U.S. Coast Guard arrived at Kure in 1961 and left Tern Island in 1979. Inset graph shows more detailed counts at Tern Island around the time of the Coast Guard's departure in July 1979. The mean 1986 count of seals at Tern Island includes data from January to July 1986.

which we believe are necessary for recovery of the Kure Atoll monk seal population.

RECOVERY ACTIVITIES

In 1981 a Head Start project was initiated at Kure Atoll in an attempt to reduce the loss of female pups, which reportedly occurred between about 2 weeks and 2-1/2 months of age (Gilmartin et al. 1986). This work involves collection of female pups each year soon after weaning and placing them in a large protective enclosure on the southwest beach of Green Island (Fig. 1). The pups are fed locally caught reef fishes until the end of the summer and then released. A total of 13 Kure-born female pups were cared for in the Head Start project in the years 1981, 1982, 1984, and 1985 (Table 1). Of these 13 seals, 11 are still at Kure. One individual of the 1981 cohort disappeared immediately after release and another, of the same year, moved to Pearl and Hermes Reef between 1985 and 1986.

Male pups have not been included in the Head Start project, but their losses have also been less than that of the previous two decades. Reduced harassment of Kure monk seals probably accounts for the improved good survival of the non-Head Start pups. Vehicle use on the beaches has been restricted, dogs are no longer allowed on the island, the beach at the north end of Green Island has been designated "off limits," the small sand islets have seasonal access restrictions, and, since 1981, National Marine Fisheries Service (NMFS) personnel have been present each year during most of the breeding season and until the end of September. The effect of the latter in reducing disturbance is due to an informal education process which occurs between NMFS and the USCG station personnel. With an understanding of the plight of the monk seal, some personnel are much more cautious not to disturb seals on the beaches. Although human disturbance is still a problem at Kure Atoll, it is reduced from the level of the previous two decades. The return of some pupping activity to Green Island supports this contention.

In 1984 a second program was initiated to aid in recovery of monk seals at Kure Atoll. Female seal pups collected in 1984 and 1985 at French Frigate Shoals which were weaned but underweight were held in Honolulu through the balance of their first summer and winter months after collection, screened for diseases and genetic problems, and then, the following spring, reintroduced to the wild as yearlings at Kure Atoll via the Head Start enclosure. Once observed catching and eating live fish in good quantity within the enclosure, the seals were released. Although the total number of seals thus added to the Kure population to date is only five, the number is significant because it equals the number of female seals born at Kure during the last 4 years (Table 1). All three of the yearlings released in this program in 1985 were resighted at Kure in 1986.

Table 1.--Birth and survival of female Hawaiian monk seals at Kure Atoll, 1981-86.

Year	No. of female births	No. in Head Start	No. surviving to t years				
			t=1	t=2	t=3	t=4	t=5
1981	6	5*	4	4	4	4	3†
1982	4	3*	3	3	3	3	
1983	0	0	--	--	--		
1984	2	2	2	2			
1985	3	3	3				
1986	0	0					

*One female pup died prior to weaning, when pups are collected for the Head Start project.

†Between age 4 and 5 years one female of this cohort moved to Pearl and Hermes Reef.

POPULATION STATUS

Census data (standardized beach counts) have been collected at Kure Atoll each year since 1981 (Appendix). Because these counts cover somewhat different time periods each year, a subset of these data covering the period 1 April-31 July was selected to compare trends among years. Table 2 presents a summary of these data as mean counts by size, sex, and island location. These data form the basis of the figures and discussion which follow.

Mean counts of adult seals show little change over the period 1981-86 (Fig. 3), but analysis of the data by size, sex, and sector reveal important trends. Noting the low survival of pups reported by Wirtz (1968) and the lack of immature seals in the 1970's, Kenyon (1980) predicted that the population of monk seals at Kure would become senescent. As already noted, this has been the case. The recent mean count of adult females has dropped steadily (Fig. 4) and the number of pups born has fallen dramatically over the last 20 years (Fig. 2). The counts of pups among years in Figure 2 are not strictly comparable because some are minimum counts of pups (counts did not cover the whole breeding season). Nevertheless, it is clear that pup production has declined sharply from the 30+ pups born per year in the 1960's to the single pup in 1986. The breeding population (i.e., those adult females known to be sexually mature) has declined to only two seals in 1986.

On the other hand, the survival of the few pups which were born at Kure during 1981-86 has been good. Table 1 presents data for female pups. Mortality (including mortality before weaning) is low overall, but appears to be higher during the first year after birth. Survival after the first year of life has been extremely high, nearly 100%, when male and female pups are considered. In addition, rehabilitated pups from French Frigate Shoals have been brought to Kure, as described earlier. This importation of young seals to Kure, together with the high survival of seals born there since 1981 and the rapid decline of older seals, has led to a population dominated by young seals. The ratio of immature to adult seals has increased to the point that in 1986 there were more immature seals (in only 4 age classes) than adult seals (in 20 or more age classes) (Fig. 4). This bodes well for the future growth of the population <u>if</u> these young seals are allowed to live and breed undisturbed.

The seals' use of different areas at the atoll has also been changing. Figure 5 shows four areas (sectors, see Fig. 1) where trends are strongest. Sector 1 on Green Island shows a significant decrease in use over the 6-year period, while Shark Island and Sectors 3 and 7 on Green Island show an increase. About half of this decrease in seal use of Sector 1, the beach between the pier and the north point "off limits" area, can be explained by the relocation of nonlactating adult females and their associated males from that area to other sites, including the sectors which showed an increase. Since an adult female monk seal will generally seek haul-out sites where disturbance is low, it is probable that disturbance has been increasing on the northwest beach (Sector 1) during this time.

Table 2.--Mean monk seal counts by size, sex, and location, Kure Atoll, 1981-86. Counts are based on census data collected between 1 April and 31 July each year. Totals with asterisk (*) include some seals which were not placed in any size class. M = male, F = female, ? = sex unknown.

	Adults			Subadults			Juveniles			Pups			
Location	M	F	?	M	F	?	M	F	?	M	F	?	Total
1981													
Green Island													
Sector 1	1.2	1.0	0.4	0.3	0.0	0.0	0.3	0.1	0.1	0.2	0.0	0.0	3.5
Sector 2	1.8	0.6	0.5	0.0	0.2	0.0	0.1	0.1	0.2	0.0	0.0	0.1	3.8*
Sector 3	0.4	0.0	0.1	0.3	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	1.0
Sector 4	0.5	0.0	0.2	0.1	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.0	1.1
Sector 5	0.3	0.3	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.3	1.0
Sector 6	0.6	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Sector 7	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2
Sector 8	0.1	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.7
Shark Island	0.2	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.1*
Sand Island	2.1	1.2	0.1	0.1	0.0	0.3	0.8	0.2	0.0	0.2	0.8	0.3	6.5*
Stark Island	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1*
Head Start pen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
Total	7.2	3.2	2.2	0.8	0.3	0.3	1.7	0.5	0.5	0.4	3.4	0.7	22.3
1982													
Green Island													
1	0.6	0.8	0.4	0.1	0.1	0.0	0.1	0.0	0.0	0.2	0.0	0.0	2.4
2	1.3	0.7	0.6	0.1	0.4	0.3	0.6	0.3	0.2	0.1	0.0	0.0	4.7
3	0.4	0.1	0.4	0.1	0.4	0.1	0.3	0.0	0.0	0.0	0.0	0.0	1.9
4	0.3	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	1.0
5	0.4	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1.2
6	0.6	0.1	0.3	0.0	0.1	0.0	0.6	0.2	0.1	0.0	0.0	0.0	2.1
7	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.6
8	0.3	0.3	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1	1.1
Shark Island	0.6	0.0	0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	1.3
Sand Island	1.9	0.3	1.1	0.2	0.3	0.3	0.3	0.6	0.3	0.0	0.0	0.0	5.2
Stark Island	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.8
Head Start pen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
Total	6.5	2.6	3.8	0.8	1.6	1.1	2.3	1.6	1.1	0.4	2.2	0.2	24.2

Table 2.--(Continued)

Location	Adults			Subadults			Juveniles			Pups			Total
	M	F	?	M	F	?	M	F	?	M	F	?	
1983													
Green Island													
Sector 1	0.4	0.4	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.3
Sector 2	1.2	0.6	0.3	0.4	0.3	0.1	0.4	0.5	0.0	0.1	0.0	0.0	3.9
Sector 3	0.9	0.2	0.2	0.2	0.8	0.0	0.2	0.2	0.0	0.1	0.0	0.0	2.8
Sector 4	0.7	0.0	0.1	0.1	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.0	1.2
Sector 5	0.4	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Sector 6	1.1	0.3	0.6	0.2	0.2	0.0	0.6	0.1	0.0	0.4	0.0	0.0	3.7
Sector 7	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.4
Sector 8	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.6
Shark Island	0.6	0.3	0.1	0.1	0.4	0.0	0.2	0.2	0.1	0.0	0.0	0.0	2.1
Sand Island	2.4	0.3	0.6	0.2	0.4	0.1	0.3	1.2	0.1	0.0	0.0	0.0	5.8*
Stark Island	0.2	0.0	0.1	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.7
Head Start pen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	8.2	2.5	2.1	1.6	2.3	0.3	2.1	2.6	0.2	1.1	0.0	0.0	23.1
1984													
1	0.3	0.2	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.9
2	0.9	0.6	0.6	0.4	0.3	0.2	0.0	0.2	0.0	0.2	0.0	0.1	3.3
3	0.7	0.2	0.3	0.2	0.2	0.2	0.0	0.3	0.0	0.5	0.0	0.0	2.6
4	0.3	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.9
5	0.5	0.1	0.3	0.2	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	1.5
6	0.4	0.1	0.3	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	1.2
7	0.2	0.0	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.6
8	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Shark Island	0.5	0.2	0.3	0.3	0.4	0.3	0.1	0.0	0.1	0.0	0.0	0.0	2.2*
Sand Island	1.7	0.7	0.7	0.6	0.5	0.3	0.4	0.4	0.1	0.2	0.4	0.0	5.9
Stark Island	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	1.4*
Head Start pen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	2.7	0.0	3.1
Total	5.6	2.4	3.4	2.0	1.6	1.5	0.7	1.0	0.3	1.8	3.1	0.1	24.2

Table 2.—(Continued)

Location	Adults			Subadults			Juveniles			Pups			Total
	M	F	?	M	F	?	M	F	?	M	F	?	
1985													
Green Island													
Sector 1	0.5	0.3	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Sector 2	1.3	0.5	0.7	0.2	0.5	0.5	0.2	0.4	0.1	0.6	0.0	0.0	4.9
Sector 3	0.6	0.2	0.2	0.2	0.5	0.2	0.1	0.0	0.0	0.5	0.0	0.0	2.4
Sector 4	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Sector 5	0.8	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Sector 6	0.9	0.1	0.2	0.2	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	1.8
Sector 7	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.8
Sector 8	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.3
Shark Island	1.1	0.1	0.1	0.5	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	2.3
Sand Island	2.1	0.3	0.5	1.6	0.8	1.2	0.3	0.0	0.0	0.0	0.0	0.0	6.8
Stark Island	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Head Start pen	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.9	0.0	1.6
Total	8.3	2.1	2.0	2.9	2.8	2.3	0.9	0.5	0.2	1.4	1.3	0.0	24.7
1986													
Green Island													
Sector 1	0.3	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Sector 2	1.3	0.5	0.6	0.6	1.0	1.5	0.0	0.5	0.4	0.0	0.0	0.0	6.4
Sector 3	0.5	0.4	0.7	0.5	0.9	0.6	0.1	0.0	0.1	0.0	0.0	0.0	3.7
Sector 4	0.5	0.1	0.1	0.2	0.4	0.1	0.0	0.1	0.1	0.0	0.0	0.0	1.5
Sector 5	0.4	0.0	0.2	0.6	0.5	0.3	0.1	0.1	0.2	0.0	0.0	0.0	2.3
Sector 6	0.5	0.2	0.4	0.7	0.1	0.3	0.0	0.0	0.1	0.1	0.0	0.0	2.3
Sector 7	0.3	0.3	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.7	0.0	0.0	1.5*
Sector 8	0.1	0.0	0.1	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Shark Island	0.4	0.3	0.2	0.3	0.6	0.3	0.0	0.1	0.3	0.0	0.0	0.0	2.5*
Sand Island	1.7	0.2	1.3	0.5	0.6	1.2	0.0	0.2	0.3	0.0	0.0	0.0	6.0
Stark Island	0.2	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Head Start pen	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Total	6.0	2.0	4.0	3.7	4.9	4.5	0.1	0.9	1.5	0.7	0.0	0.0	28.5

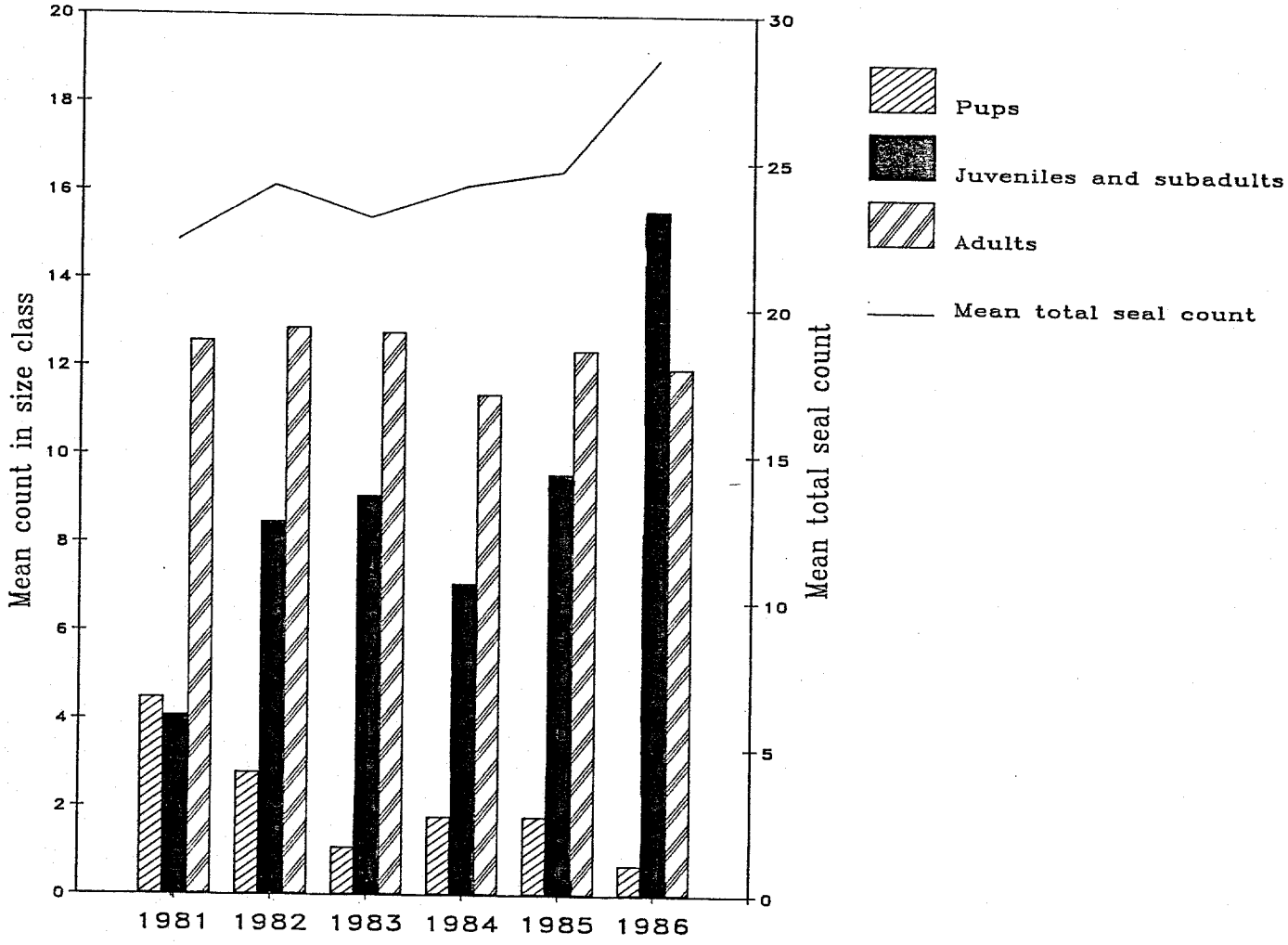

Figure 3.--Mean counts of monk seals in three size classes (bars) and mean total seal count (line) at Kure Atoll, 1981-86.

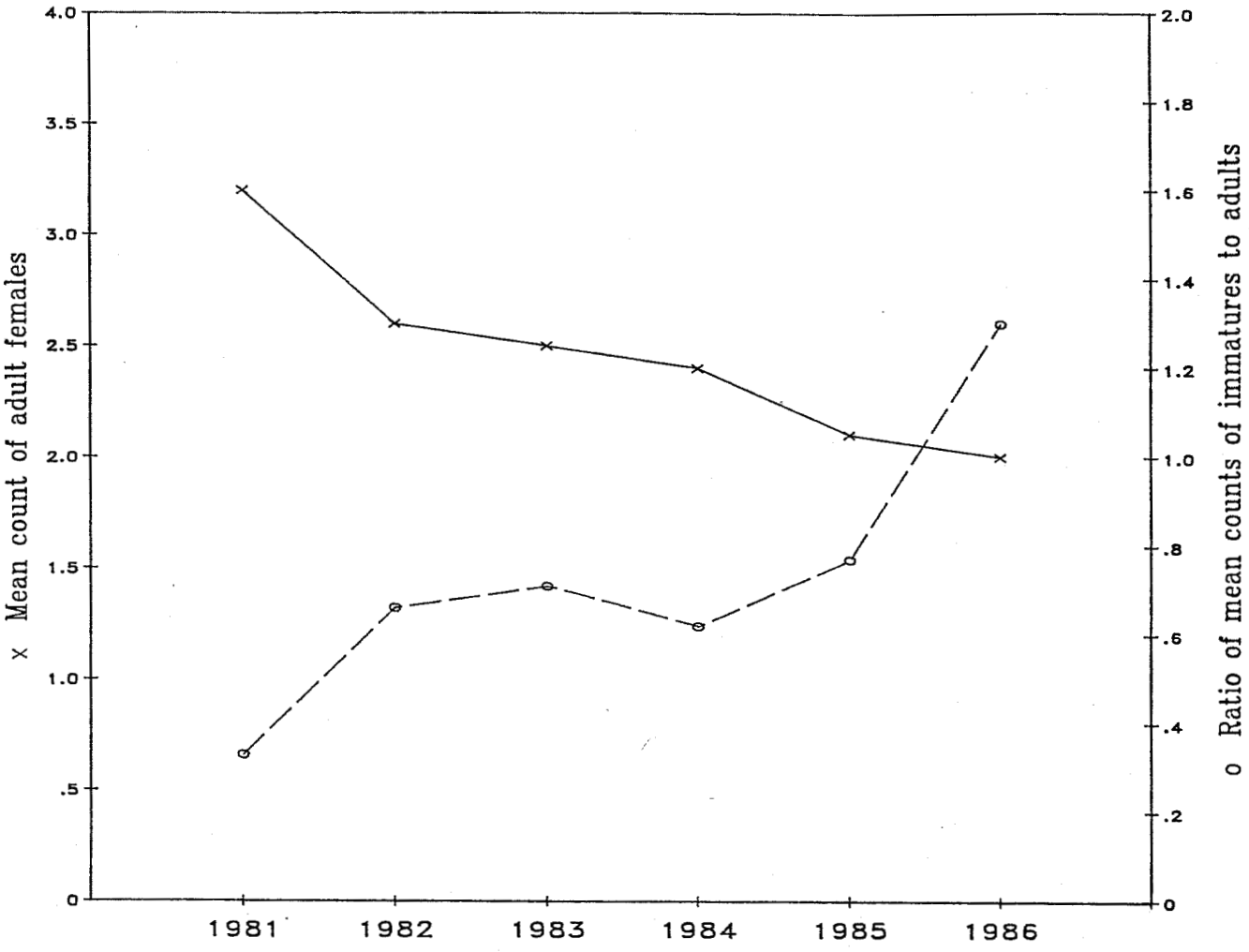

Figure 4.--Mean count of adult female monk seals (solid line) and ratio of mean count of immatures (= juveniles + subadults) to mean count of adults (dashed line) at Kure Atoll, 1981-86.

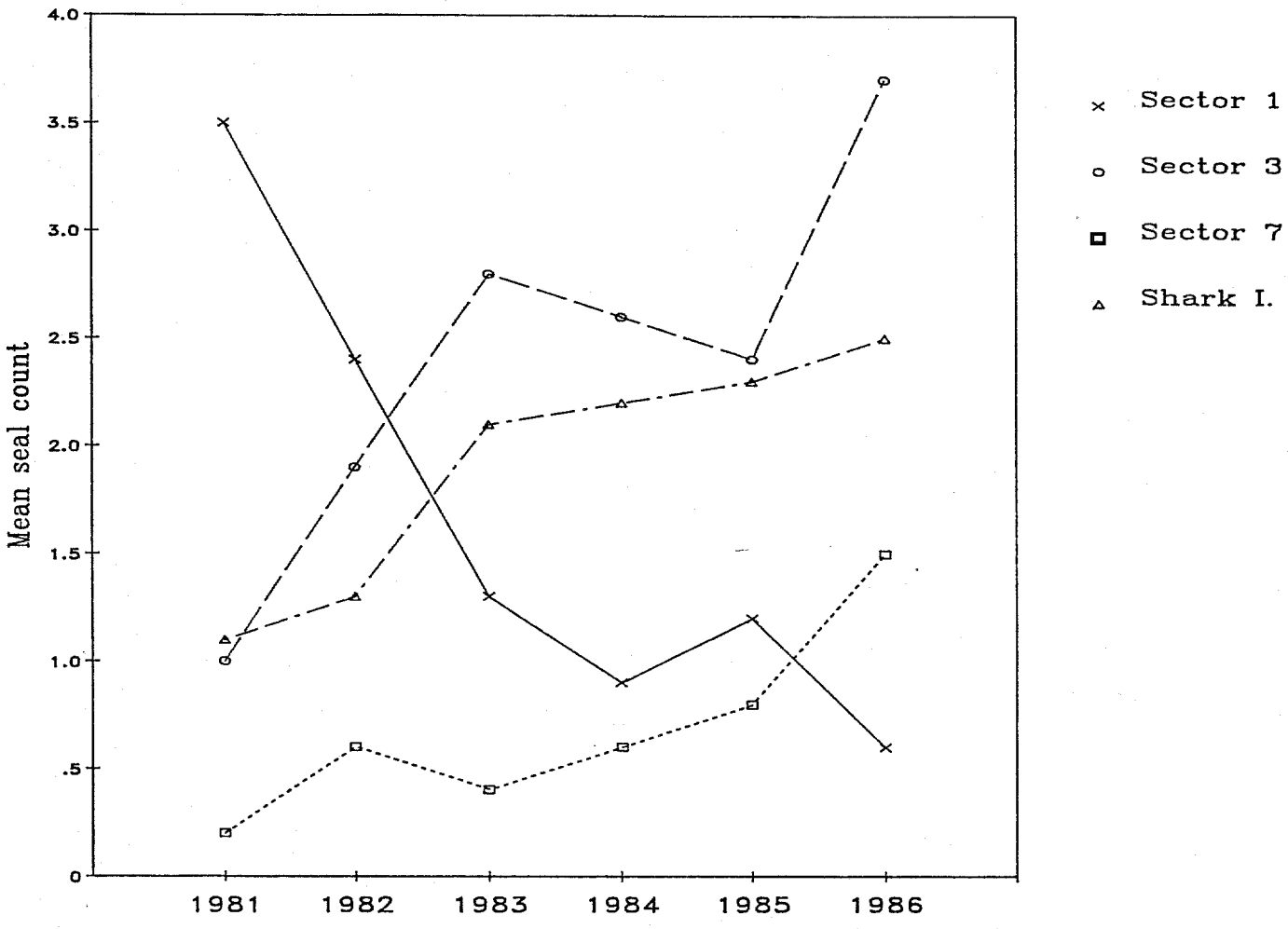

Figure 5.--Mean counts of seals on Shark Island and three sectors of Green Island, Kure Atoll, 1981-86. See Figure 1 for map of sectors on Green Island.

POPULATION MODEL PROJECTIONS

The intensive studies which have been conducted at Kure and at other islands in the Hawaiian Archipelago at which monk seals live allow the construction of a simple population projection model to predict the future growth of the Kure Atoll population of monk seals. The model is an age-structured, discrete-time, females-only model with the adult age classes collapsed into a single pool of breeding females. The quantities required for input to the model are:

1. Current (1986) number of females in each age category. These are known from tagging conducted at Kure since 1981 and from identification of older seals on the basis of scar patterns.

2. Age at first reproduction. The pups born at Kure in 1981 are now 5 years old. None of them reproduced in 1986, although they were of large subadult and adult size. We have assumed, based on the only available data, that they will breed at the age of 6 years. The youngest monk seal of known age observed to give birth was 7 years old at the time (Johnson and Johnson 1984).

3. Birth rate (live female births per female per year). Because so few pups have been born at Kure, the birth rate was calculated from other islands at which the exact number of adult females was known. The mean birth rate at Lisianski Island in 1982 and 1983 and Laysan Island in 1983 was estimated to be 0.31.

4. Interatoll movement. For computational simplicity, gains or losses of seals due to interatoll movement are incorporated into the survival rate estimates (see below). We assume, perhaps optimistically, that the fidelity to Kure of the translocated French Frigate Shoals yearlings will be the same as Kure-born seals. Interatoll movement of tagged seals has been low; a single 4-year-old female moved from Kure to Pearl and Hermes Reef between 1985 and 1986 (Table 1). In addition, no movement of known adult Kure females to other atolls has been observed.

5. Survival rates. Annual survival rates were estimated for three age categories as follows:

    a. Pups (from birth to age 1 year). Of 15 female pups born at Kure since 1981, 12 have survived to their first birthday (Table 1). The pup survival rate at Kure is therefore set at 0.8.

    b. Immatures (from age 1 to 6). As noted above, survival for these ages has been extremely high at Kure during 1981-86. On the basis of the data in Table 1, the annual immature survival rate was calculated to be 0.977 (only one loss due to emigration). This survival rate is so high that it should be questioned whether it is a realistic long-term average; rather, it is a survival rate which was observed during a

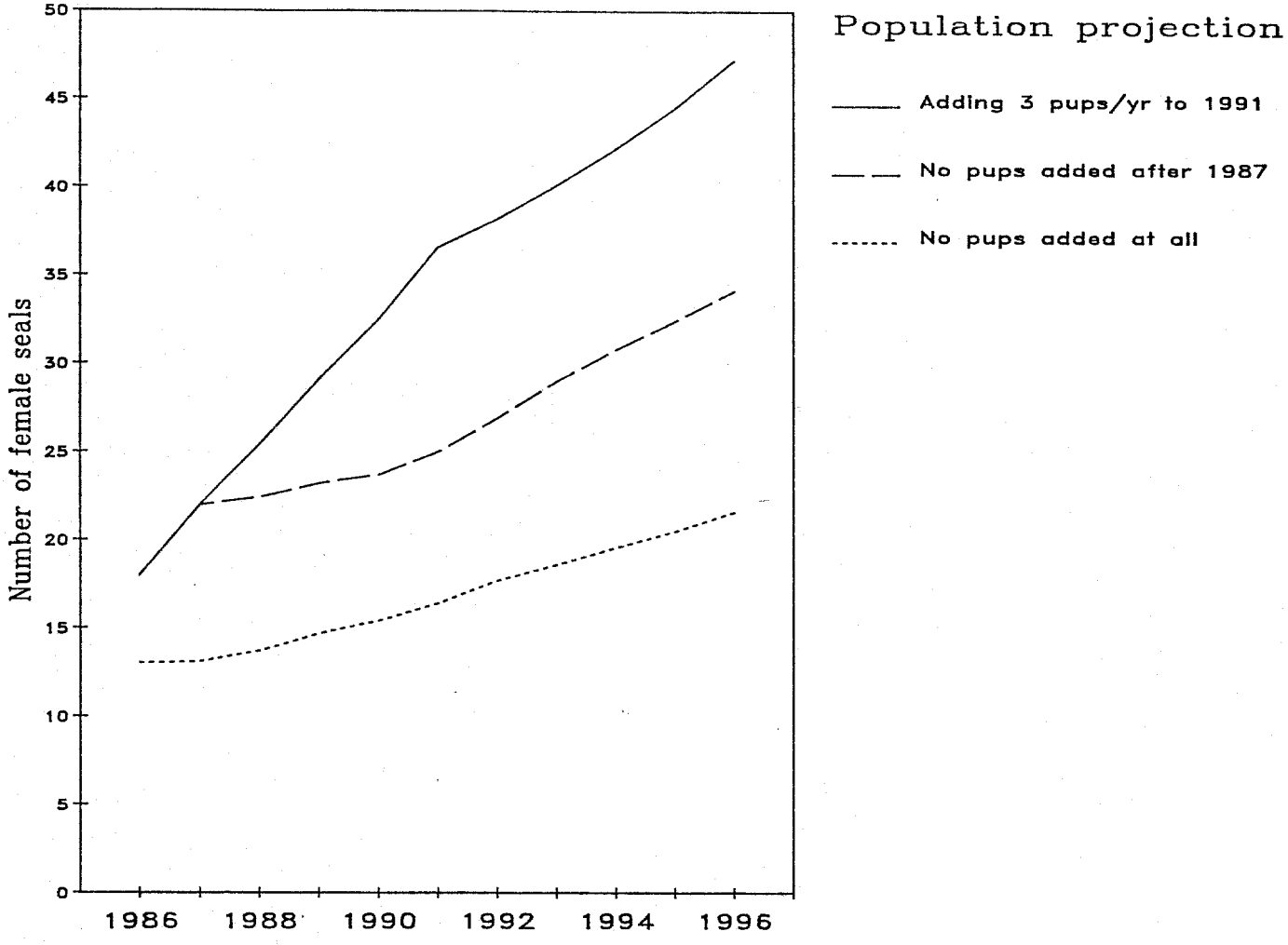

Figure 6.--Ten-year population projections of the female monk seal population at Kure Atoll, based on the population model described in the text. Three scenarios are shown, based on different management options for translocating female pups to Kure: No pups added at all, no more pups added after 1987, when pups currently in Honolulu are due to be released, and adding three pups per year through 1991.

time which evidently was favorable for survival of these ages.

c. Adults (age 6 and older). Since the adult population at Kure consisted of old animals from 1981 to 1986, we feel that survival rates based on the observed decline of these old seals would not apply to the adult age category as a whole. Therefore, the mean annual adult female survival rate of 0.908 (including losses due to emigration) were calculated from Lisianski between 1982 and 1983, and from Laysan Island between 1984 and 1985. This is a high adult survival rate compared to other pinnipeds. As with the immature rate, it should be viewed as a survival rate which applies over a short favorable time.

Given the current population structure and these estimates of the vital rates, the Kure population can be projected into the future. As a first step, we have projected what the course of the population would be if there had been no introduction of female pups to Kure over the last 2 years (Fig. 6, bottom curve). Next, we have projected the population with introductions of pups which have already occurred, including four female pups currently being rehabilitated in Honolulu for release at Kure in 1987 (Fig. 6, middle curve). The difference between these two curves gives an idea of the value of the translocation program to date. Finally, we have projected the population assuming the translocation program will continue to introduce three female yearlings per year to Kure through 1991 (top curve in Fig. 6).

In all cases the Kure female population is projected to grow during the next 10 years, even if no additional seals are introduced. This is simply a result of our choice of vital rates, particularly the high survival rates. If these rates are inaccurate, or if they become lower in the future due to human disturbance, disease, food shortage, or other factors, the population will not grow as shown. Therefore, our interest is not so much in how fast the population is expected to grow, but in the relative differences between the different projections, which will remain regardless of the choice of vital rates. The introduction of rehabilitated pups from French Frigate Shoals has already made an important contribution to the potential growth rate of the Kure population. Continuing this program through 1991 will make a significant additional contribution (note the difference between the middle and top curves in Fig. 6). Moreover, the difference between the curves will continue to grow in the future, since yearlings introduced to Kure in the 1980's are just beginning to make a reproductive contribution by 1996.

RECOMMENDATIONS

The 1986 reproductive population at Kure Atoll is at its lowest known level: One pup born of two known adult females. The recovery actions to date, Head Start, the relocation of young females to Kure and reduced beach disturbance, have had beneficial effects. This is apparent in the

increasing size of the immature age class. Nevertheless, the number of animals at Kure is very low and the population is in great jeopardy. The highly skewed adult sex ratio may lead to the deaths of young females from attacks by adult males, as has been observed at Laysan and Lisianski Islands (Alcorn 1984; Gerrodette 1985; Johanos and Kam 1986). A natural catastrophe, such as a ciguatera die-off, could easily erase all of the progress to date in bolstering the immature seal count. An increase in beach disturbance could have a similar effect, or even the present level of disturbance may not be tolerable to these maturing females, causing them to move to other breeding islands.

It is very important, therefore, that certain activities and restrictions be continued and that additional measures be taken to maintain or increase, as may be possible, survival, fidelity, and recruitment of females to the Kure population. The following recommendations appear critical to accomplish these goals:

1. Continue Head Start as long as the USCG remains at Kure Atoll or until beach disturbance is significantly reduced by USCG personnel reductions or changes in regulations and enforcement of them.

2. Continue and increase, if possible, the number of females relocated to Kure through rehabilitation and the Head Start project.

3. Reduce USCG disturbance of monk seals at Kure Atoll:

    a. Enforce current "off limits" restriction at the north point of Green Island and seasonal access restriction on the sand islets.

    b. Continue restricted use of vehicles on Green Island beaches, only as essential to support USCG mission, NMFS research, or State needs.

    c. Add the west point of Green Island, Sectors 5, 6, and 7, as a seasonally restricted beach, from 1 February to 1 August, and cut footpaths through the vegetation to allow beach walkers to easily bypass this area during this period (Fig. 2). Historically, this beach area has been preferred monk seal pupping habitat and it is critical that disturbance here be reduced to encourage females to remain and successfully rear pups at Kure Atoll.

    d. Restrict all non-station personnel visiting Kure from access to any of the outer islands and all Green Island beaches, except the main recreational beach between the pier and the NMFS monk seal pup enclosure on the west shore of the island (Fig. 1, Sector 8), unless access to other areas is specifically authorized by State permits.

e. The current station order calling for a minimum approach distance to seals of 30.5 m (100 ft) should be strictly enforced. A 61 m (200-ft) limit should be the minimum distance any restricted beach or island may be approached from the water.

f. The USCG should designate a Wildlife Officer from within the USCG to serve in such a capacity. The Wildlife Officer should coordinate his activities with the NMFS Senior Resident Agent.

g. Emphasis on an educational program for visitors and new USCG assignees should be continued.

4. Consider applying results of experimental work at Laysan Island to Kure, if adult male induced female mortality appears to be impeding recovery.

5. Monitor the Kure Atoll monk seal population closely. Population size and composition, survival rates, birth rates, interatoll movement (especially of relocated females), and intra-atoll haul-out patterns should be checked annually to enable a quick response to any apparent problems.

The endangered Hawaiian monk seal breeding population has almost been eliminated at Kure Atoll. Although there is hope that it can survive and increase in the near future, based on the growing number of immature females, there seems little cause for this optimistic view based on what has occurred there over the last 20 years. Our recovery projections are based on the very critical assumption that the future will be different than the past, that beach disturbance of monk seals by USCG personnel will be further reduced. If the recommendations listed above to reduce this disturbance are not implemented soon, it is likely that the effort which has gone into building the immature population will fail to establish a breeding population.

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APPENDIX

Monk seal beach counts at Kure Atoll, 1981-86. Totals with asterisk (*) include some seals which were not placed in any size class. M = male, F = female, ? = sex unknown.

	Non-pups									Pups						Totals		
	Adult			Subadult			Juvenile			Weaned			Nursing					
Date	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	Non-pup	Pup	Grand
1981																		
4/1	9	3	0	1	0	0	2	1	0	1	0	0	0	0	3	17*	4	21
4/3	13	3	4	1	1	1	1	0	0	1	0	0	0	0	3	25*	4	29
4/16	6	4	4	1	1	1	0	0	1	1	0	0	1	2	1	18	5	23
5/21	5	2	4	0	0	0	1	0	1	1	0	0	0	0	1	19*	2	21
6/17	8	6	5	1	1	1	0	0	0	0	3	0	0	2	0	22	5	27
6/21	5	3	3	1	0	1	1	2	0	0	3	0	0	2	0	18*	5	23
6/25	10	3	1	0	1	0	4	0	0	0	3	0	0	1	0	19	4	23
7/11	4	2	2	0	0	0	0	0	1	0	3	0	0	2	0	9	5	14
7/17	5	2	1	1	0	0	3	1	0	0	5	0	0	0	0	14*	5	19
7/21	9	3	1	2	0	0	2	1	2	0	5	0	0	0	0	20	5	25
7/25	7	4	2	2	0	0	3	1	0	0	5	0	0	0	0	21*	5	26
7/29	5	3	0	0	0	0	3	0	1	0	5	0	0	0	0	17*	5	22
8/2	7	6	6	1	0	0	2	1	0	0	5	0	0	0	0	23	5	28
8/6	9	2	3	0	1	3	1	0	0	1	5	0	0	0	0	19	6	25
8/16	7	0	3	2	0	3	1	0	1	0	5	0	0	0	0	17	5	22
8/20	8	3	8	2	0	1	2	2	0	0	5	0	1	0	0	27*	6	33
8/24	13	5	2	0	0	1	1	1	2	1	5	0	1	0	0	26*	7	33
8/28	7	2	6	2	0	2	0	0	0	1	5	0	1	0	0	19	7	26
9/1	15	1	8	1	0	1	2	0	1	0	5	0	0	0	0	30*	5	35
9/5	18	1	4	3	1	1	3	1	0	0	2	0	1	0	0	32	3	35
9/13	15	2	8	1	1	2	2	1	0	1	2	0	1	0	0	32	4	36
1982																		
3/24	16	3	8	3	1	0	2	1	3	0	0	0	0	0	1	37	1	38
4/17	10	4	5	1	2	1	1	0	3	0	1	0	0	0	2	27	3	30
4/22	9	3	6	0	1	2	3	3	0	0	1	0	0	0	2	27	3	30
4/26	7	1	5	0	3	2	1	1	0	0	0	0	0	0	1	20	1	21
4/30	10	2	2	1	2	1	2	0	1	0	1	0	0	1	0	21	2	23
5/5	3	4	6	0	2	2	3	2	4	0	1	0	0	1	1	27*	3	30
5/10	9	4	2	0	3	1	3	2	1	0	1	0	0	2	0	25	3	28
5/14	9	2	4	1	2	2	1	3	2	0	2	0	0	1	0	26	3	29
5/19	7	2	5	0	1	0	3	4	0	0	2	0	0	0	0	22	2	24
5/25	3	3	3	0	2	3	2	1	2	0	2	0	0	0	0	20*	2	22
5/29	13	3	3	1	1	1	4	1	0	0	3	0	0	0	0	28*	3	31
6/1	3	2	8	1	2	2	5	1	1	0	3	0	0	0	0	26*	3	29

Appendix.--(Continued)

	Non-pups									Pups						Totals		
	Adult			Subadult			Juvenile			Weaned			Nursing					
Date	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	Non-pup	Pup	Grand
6/5	10	2	3	1	3	0	1	2	1	0	3	0	0	0	0	24*	3	27
6/9	10	5	3	1	0	0	4	3	1	0	3	0	0	0	1	29*	4	33
6/13	6	2	3	0	3	1	3	3	0	0	2	0	1	0	0	22*	3	25
6/17	8	2	4	1	2	1	3	0	1	0	2	0	1	0	0	23*	3	26
6/21	2	4	5	2	1	0	4	3	1	0	0	0	1	0	0	23*	1	24
6/25	7	2	3	2	3	1	6	2	0	0	3	0	1	0	0	28*	4	32
6/29	10	4	4	0	2	1	7	4	1	0	3	0	1	0	0	33	4	37
7/3	6	3	3	1	0	1	2	2	1	0	3	0	1	0	0	20*	4	24
7/6	5	3	6	2	2	0	0	1	2	0	3	0	0	0	0	22*	3	25
7/9	13	2	3	0	0	0	1	2	0	1	3	0	0	0	0	21	4	25
7/10	5	5	5	0	1	1	2	1	1	0	0	0	1	0	0	23*	1	24
7/14	5	3	3	2	1	3	3	0	4	0	2	0	1	0	0	26*	3	29
7/18	10	4	1	1	0	1	2	1	1	0	2	0	0	0	0	23*	2	25
7/22	6	1	5	2	1	1	0	2	0	1	2	0	0	0	0	18	3	21
7/26	6	4	3	2	3	1	1	1	1	1	3	0	0	0	0	23*	4	27
7/30	5	0	5	2	2	1	0	1	1	1	3	0	0	0	0	19*	4	23
8/5	6	2	1	5	1	0	1	0	0	1	3	0	0	0	0	17*	4	21
1983																		
4/27	5	0	2	1	2	0	3	3	2	1	0	0	0	0	0	19*	1	20
4/29	11	1	3	2	3	0	2	3	0	1	0	0	1	0	0	26*	2	28
5/1	10	3	2	1	3	1	2	4	0	1	0	0	1	0	0	28*	2	30
5/3	11	1	4	4	4	2	2	3	2	0	0	0	1	0	0	33	1	34
5/5	10	2	4	1	2	0	3	6	0	1	0	0	0	0	0	29*	1	30
5/7	6	2	5	0	3	0	3	3	0	1	0	0	1	0	0	23*	2	25
5/9	9	5	2	1	3	0	1	4	0	0	0	0	1	0	0	26*	1	27
5/11	8	0	4	2	3	0	3	3	0	0	0	0	0	0	0	23	0	23
5/13	7	3	1	0	3	0	1	2	0	1	0	0	1	0	0	18*	2	20
5/15	5	1	4	1	3	0	1	3	0	1	0	0	0	0	0	19*	1	20
5/17	12	4	4	2	2	0	1	3	0	1	0	0	1	0	0	28	2	30
5/19	9	3	3	1	4	0	2	4	0	0	0	0	1	0	0	27*	1	28
5/21	8	4	2	2	2	2	2	4	0	1	0	0	0	0	0	27*	1	28
5/23	7	3	1	2	3	0	3	3	0	1	0	0	0	0	0	23*	1	24
5/25	9	3	2	3	2	0	3	2	0	0	0	0	0	0	0	25*	0	25
5/27	9	2	2	2	2	1	2	1	0	1	0	0	0	0	0	21	1	22
5/29	10	3	1	2	2	0	1	2	0	2	0	0	0	0	0	22*	2	24
5/31	11	2	3	2	2	0	2	1	1	2	0	0	0	0	0	24	2	26
6/2	10	4	4	3	2	0	2	3	0	1	0	0	0	0	0	29*	1	30
6/4	4	3	2	2	2	0	2	3	0	1	0	0	0	0	0	18	1	19
6/6	6	3	1	2	1	0	2	2	0	0	0	0	0	0	0	17	0	17
6/8	6	3	0	2	2	0	3	2	0	1	0	0	0	0	0	18	1	19

Appendix.--(Continued)

	Non-pups									Pups						Totals		
	Adult			Subadult			Juvenile			Weaned			Nursing					
Date	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	Non-pup	Pup	Grand
6/10	6	1	1	2	1	1	2	2	1	0	0	0	0	0	0	17	0	17
6/12	9	2	1	0	2	0	2	1	1	0	0	0	0	0	0	18	0	18
6/14	7	4	1	1	1	0	3	1	0	0	0	0	0	0	0	18	0	18
6/16	12	2	1	1	1	1	3	2	0	1	0	0	0	0	0	23	1	24
6/20	4	3	1	1	2	1	1	1	0	0	0	0	0	0	0	15*	0	15
6/24	8	3	0	2	1	0	1	3	0	1	0	0	1	0	0	19*	2	21
6/28	9	3	0	2	3	0	3	1	0	2	0	0	1	0	0	22*	3	25
1984																		
5/14	12	1	6	2	4	4	3	1	1	0	1	0	0	0	0	35*	1	36
5/16	7	1	5	0	3	7	1	0	0	1	0	0	1	0	0	25*	2	27
5/18	9	1	0	3	2	1	1	0	0	2	0	0	0	0	0	18*	2	20
5/21	5	0	3	2	3	0	0	1	0	3	1	0	0	0	0	14	4	18
5/23	6	1	1	1	2	0	0	1	1	2	0	0	0	0	0	14*	2	16
5/25	11	1	4	2	4	2	1	1	0	2	1	0	0	0	0	27*	3	30
5/27	6	0	3	4	2	2	0	1	0	2	1	0	0	0	0	18	3	21
5/30	7	3	1	4	1	1	1	1	0	1	0	0	0	1	0	20*	2	22
6/1	6	1	1	4	3	0	0	0	0	1	1	0	0	1	0	17*	3	20
6/4	5	4	2	2	0	0	0	0	0	1	1	0	0	1	0	14*	3	17
6/6	7	2	3	4	0	0	1	1	0	2	0	0	0	1	0	18	3	21
6/10	4	2	9	1	0	1	0	0	0	2	3	0	0	1	0	18*	6	24
6/12	7	2	4	1	2	1	1	1	0	0	3	0	0	1	0	19	4	23
6/14	5	3	10	3	2	0	1	1	0	1	2	0	0	1	0	25	4	29
6/16	8	1	3	4	1	1	0	0	1	1	3	0	0	0	0	19	4	23
6/18	3	3	5	1	0	2	0	1	0	1	1	0	0	1	0	15	3	18
6/20	11	4	1	2	4	0	0	1	1	2	0	0	0	1	0	24	3	27
6/22	4	3	3	2	2	0	0	1	1	1	3	0	0	0	0	16	4	20
6/24	5	4	4	1	0	1	0	1	4	2	2	0	0	1	0	21*	5	26
6/26	1	3	1	2	1	1	2	2	0	2	4	0	0	1	0	14*	7	21
6/28	5	4	5	1	2	0	1	3	1	2	2	0	0	1	0	23*	5	28
6/30	4	5	3	1	1	0	0	1	0	1	2	0	0	1	0	16*	4	20
7/2	3	4	1	3	0	1	1	1	1	1	3	0	1	0	0	15	5	20
7/4	5	4	2	2	2	2	2	2	0	1	5	0	1	0	0	21	7	28
7/6	3	3	2	2	2	2	1	1	0	2	5	0	1	0	0	17*	8	25
7/8	3	2	3	1	2	4	1	0	1	1	5	0	1	0	0	18*	7	25
7/10	1	2	4	0	2	5	0	2	0	1	5	0	0	0	1	17*	7	24
7/14	3	4	6	0	2	4	0	2	0	2	5	1	0	0	1	21	9	30
7/16	5	3	4	3	3	2	1	0	0	2	5	0	1	0	0	21	8	29
7/18	6	3	3	2	1	3	2	2	0	1	5	0	0	0	0	22	6	28
7/19	9	2	1	4	1	3	2	1	0	2	5	0	1	0	0	23	8	31
7/22	4	2	3	2	0	1	0	2	0	3	5	0	1	0	0	15*	9	24

Appendix.--(Continued)

	Non-pups									Pups						Totals		
	Adult			Subadult			Juvenile			Weaned			Nursing					
Date	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	Non-pup	Pup	Grand
7/24	6	3	5	0	0	1	1	1	0	1	5	0	1	0	0	19*	7	26
7/26	6	2	2	2	1	1	0	1	0	2	5	0	1	0	0	16*	8	24
7/28	4	1	5	2	2	0	0	1	0	1	5	0	0	0	0	16*	6	22
7/30	7	2	6	3	2	2	0	0	0	1	5	0	1	0	0	23*	7	30
8/1	6	4	4	2	2	1	1	1	0	2	5	0	1	0	0	21	8	29
8/3	4	2	8	0	1	1	0	0	1	0	5	0	1	0	0	18*	6	24
8/5	4	2	7	2	2	1	1	1	0	0	5	0	1	0	0	20	6	26
8/9	8	1	7	3	0	1	0	0	0	4	3	0	0	0	0	21*	7	28
8/11	4	0	12	1	1	0	2	0	0	3	5	0	0	0	0	21*	8	29
8/13	3	3	10	0	1	0	1	0	0	2	5	0	0	0	0	19*	7	26
8/17	7	1	5	3	2	1	0	0	0	1	5	0	0	0	0	20*	6	26
8/21	5	0	10	1	2	2	1	0	0	2	5	0	0	0	0	22*	7	29
8/26	8	1	9	0	0	1	1	1	0	1	3	0	0	0	0	23*	4	27
8/29	9	1	2	2	0	0	1	1	0	1	4	0	0	0	0	18*	5	23
9/2	14	2	3	4	1	1	3	0	1	3	4	0	0	0	0	30*	7	37
9/6	7	1	11	1	1	2	1	1	0	3	3	0	0	0	0	26*	6	32
9/15	12	2	8	1	0	1	1	1	0	2	4	0	0	0	0	28*	6	34
9/18	7	1	14	3	0	4	0	0	0	1	4	0	0	0	0	31*	5	36
9/24	11	1	13	0	1	3	0	0	0	2	1	0	0	0	0	30*	3	33
1985																		
2/5	9	3	7	1	4	5	2	1	2	0	0	0	1	0	0	34	1	35
2/23	10	4	6	5	3	2	2	1	1	0	0	0	2	0	0	34	2	36
3/13	11	2	8	2	2	2	3	1	2	0	0	0	2	0	0	33	2	35
3/17	7	5	5	4	1	6	2	0	3	1	0	0	1	0	0	33	2	35
4/2	8	1	3	2	1	4	1	0	0	2	0	0	0	0	0	20	2	22
4/8	6	3	5	2	2	1	4	0	0	1	0	0	0	1	0	23	2	25
4/10	10	2	4	0	0	3	1	2	0	1	0	0	0	1	0	22	2	24
4/30	11	5	5	3	3	1	1	0	0	2	0	0	0	2	0	29	4	33
5/22	8	2	4	4	2	3	2	1	0	2	0	0	0	0	0	26	2	28
5/24	12	3	4	2	2	2	2	1	0	0	0	0	0	1	0	28	1	29
5/26	11	4	6	4	1	3	0	0	1	1	0	0	0	0	0	30	1	31
5/28	6	2	2	5	0	3	1	0	0	1	1	0	0	0	0	19	2	21
5/30	5	3	3	1	3	1	0	0	2	2	0	0	0	1	0	18	3	21
6/1	10	1	1	4	1	4	0	0	0	2	1	0	0	0	0	21	3	24
6/3	7	2	2	2	3	2	2	2	0	0	0	0	0	0	0	22	0	22
6/5	11	0	0	1	4	6	2	0	0	2	2	0	0	0	0	24	4	28
6/7	8	2	1	3	5	1	0	0	0	0	2	0	0	0	0	20	2	22
6/9	7	2	0	3	4	2	1	1	0	2	2	0	0	0	0	20	4	24
6/13	7	3	0	2	3	5	1	1	0	1	1	0	0	0	0	22	2	24
6/17	3	2	1	3	3	3	1	1	0	0	0	0	0	0	0	17	0	17

Appendix.--(Continued)

	Non-pups									Pups						Totals		
	Adult			Subadult			Juvenile			Weaned			Nursing					
Date	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	Non-pup	Pup	Grand
6/19	7	2	0	1	1	1	1	0	0	1	1	0	0	0	0	13	2	15
6/22	8	2	1	3	7	0	1	0	0	1	2	0	0	0	0	22	3	25
6/24	10	1	2	2	5	2	1	0	0	1	1	0	0	0	0	23	2	25
6/26	10	2	3	5	3	2	0	0	0	2	2	0	0	0	0	25	4	29
6/28	6	1	2	2	1	4	0	1	0	1	1	0	0	0	0	17	2	19
7/2	10	1	1	3	5	0	2	1	0	1	2	0	0	0	0	23	3	26
7/6	12	2	3	5	1	5	1	1	1	2	1	0	0	0	0	31	3	34
7/12	8	1	1	5	6	3	0	0	0	2	1	0	0	0	0	24	3	27
7/14	8	5	1	2	4	3	1	0	0	0	1	0	0	0	0	24	1	25
7/16	8	2	0	5	3	1	1	0	0	2	1	0	0	0	0	20	3	23
7/18	4	2	1	2	3	2	2	0	0	2	1	0	0	1	0	16	4	20
7/20	4	1	0	1	2	3	1	1	0	1	1	0	0	1	0	13	3	16
7/22	5	1	3	4	4	0	0	0	1	2	2	0	0	1	0	18	5	23
7/24	12	3	0	5	6	1	0	1	0	2	2	0	0	1	0	28	5	33
7/26	9	2	3	3	2	0	0	1	0	2	1	0	0	1	0	20	4	24
7/28	13	1	2	4	3	2	0	1	0	2	1	0	0	1	0	26	4	30
7/30	9	3	2	3	1	3	0	1	0	2	1	0	0	1	0	22	4	26
8/1	8	4	1	3	1	2	1	0	1	1	0	0	0	0	0	21	1	22
8/3	10	1	2	2	1	2	2	1	0	1	0	0	0	0	0	21	1	22
8/5	12	4	1	3	1	1	1	0	0	1	1	0	0	1	0	23	3	26
8/7	8	3	3	4	1	1	1	1	0	1	2	0	0	1	0	22	4	26
8/9	11	2	1	2	1	2	1	1	0	2	2	0	0	1	0	21	5	26
8/13	4	2	0	3	1	3	1	1	0	2	1	0	0	1	0	15	4	19
8/15	8	0	1	2	1	0	1	1	0	1	2	0	0	0	0	14	3	17
8/17	11	3	1	4	1	0	0	1	0	1	1	0	0	1	0	21	3	24
8/18	10	2	2	4	0	0	1	1	0	1	0	0	0	1	0	20	2	22
8/20	12	0	0	2	1	0	0	1	0	1	2	0	0	0	0	16	3	19
8/27	7	2	3	2	4	0	0	1	0	1	3	0	0	0	0	19	4	23
8/29	8	1	4	3	1	1	1	1	0	2	3	0	0	0	0	20	5	25
8/31	8	3	2	2	0	2	0	1	0	1	1	0	0	0	0	18	2	20
9/4	15	2	5	0	4	0	1	1	0	1	2	0	0	0	0	28	3	31
9/6	17	1	1	3	3	0	1	0	0	1	1	0	0	0	0	26	2	28
9/10	12	1	3	5	2	1	1	1	0	1	0	0	0	0	0	26	1	27
9/14	12	1	3	4	2	1	0	1	0	1	1	0	0	0	0	24	2	26
9/16	17	0	0	8	3	0	1	0	0	2	1	0	0	0	0	29	3	32
9/18	13	2	4	5	2	2	0	0	0	2	1	0	0	0	0	28	3	31
9/24	11	1	11	5	3	2	1	2	1	2	0	0	0	0	0	37	2	39
9/28	11	1	6	5	4	6	1	1	0	2	2	0	0	0	0	35	4	39
9/30	14	3	5	4	2	1	1	1	0	1	3	0	0	0	0	31	4	35

Appendix.--(Continued)

	Non-pups									Pups						Totals		
	Adult			Subadult			Juvenile			Weaned			Nursing					
Date	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	Non-pup	Pup	Grand
1986																		
5/21	5	2	6	5	7	1	0	2	1	0	0	0	1	0	0	29	1	30
5/24	8	2	3	1	6	6	0	0	3	0	0	0	1	0	0	29	1	30
5/26	9	1	2	4	3	5	1	1	3	0	0	0	1	0	0	29	1	30
5/27	7	2	4	4	5	8	0	2	2	0	0	0	1	0	0	34	1	35
5/29	6	3	5	4	4	3	0	4	1	0	0	0	0	0	0	31*	0	31
5/30	8	2	5	7	1	5	0	1	6	1	0	0	0	0	0	35	1	36
6/1	4	3	6	3	5	5	1	0	1	1	0	0	0	0	0	28	1	29
6/3	3	1	6	1	4	9	0	0	1	1	0	0	0	0	0	25	1	26
6/5	5	2	2	3	7	1	0	1	0	1	0	0	0	0	0	21	1	22
6/6	2	1	4	5	6	5	0	0	1	1	0	0	0	0	0	24	1	25
6/8	4	3	3	4	5	5	0	1	0	0	0	0	0	0	0	25	0	25
6/10	6	1	4	3	7	5	0	0	1	1	0	0	0	0	0	27	1	28
6/12	11	2	1	5	5	3	0	0	1	0	0	0	0	0	0	28	0	28
6/14	7	2	3	4	5	4	0	0	0	1	0	0	0	0	0	26*	1	27
6/16	5	3	6	3	4	2	0	2	1	0	0	0	0	0	0	26	0	26